Application No. 10/519,046
Filed: August 19, 2005
TC Art Unit: 4145
Confirmation No.: 6619

REMARKS

Claims 1, 2 and 4-9 remain pending in this application. Claim 1 has been amended to incorporate the limitations of claim 3. Claim 1 has also been amended to clarify that the measurement of the apparent viscosity is meant to be taken at 20 deg. C above the melting point of the wholly aromatic liquid crystal polymer. Support for this amendment can be found in the Specification at, for example, page 8, lines 12-15. In view of these amendments, claim 3 has been cancelled and dependent claim 8 has been amended to remove the limitation regarding the viscosity of the liquid crystal polymer.

Claim 2 has been amended to clarify the language as suggested by the Examiner. Claims 6 and 9 have been amended to clarify that the molded product has a portion with a thickness of 0.5 mm or less. In view of these amendments, it is believed that the indefiniteness rejections are all overcome.

In the Specification, the Abstract has been amended to overcome the objection for excessive length.

In the Office Action, claims 1-9 were rejected under 35 U.S.C. § 103(a) as being obvious over U.S. 2002/0012862 to Maeda ("Maeda") in view of U.S. 5,837,366 to Tanaka ("Tanaka"). For the

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following reasons, it is respectfully submitted that these rejections are overcome and that all claims are allowable.

According to the present invention as defined in the present claims, a molded product includes a wholly aromatic liquid crystal polyester and has a dielectric constant of 3.0 or less and a dielectric dispersion factor of 0.04 or less. Applicants have discovered that unexpected results are obtained by using a liquid crystal polyester having an excellent flowability. It is believed that the increased flowability reduces the fracture rate of a hollow filler material during the molding process, and provides benefits with respect to the dielectric properties of the resultant molded product. Independent claim 1 has been amended to clarify the flowability of the liquid crystal polyester having an apparent viscosity of 5,000 poise or less at a temperature that is 20 deg. C above the melting point of the liquid crystal polymer.

As discussed in the present Specification at, for example, page 2, lines 12-31, an object of the present invention is to provide a molded product that has the dielectric property that the conventional liquid crystal polyester has not realized. Conventional liquid crystal polyester resins can possess good processibility, stability and heat resistance, but these materials generally have a relatively high dielectric constant (e.g., 3.0 or

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greater). One technique for decreasing the relative dielectric constant of a molded product is to compound spherical hollow material fillers containing air with the liquid crystal polyester and any additional inorganic fillers. However, if the finished molded part is produced by injection molding, the compounded hollow filler is often destroyed so that the improvement in the relative dielectric constant is not realized. This problem is particularly acute when the finished molded product includes a thin portion (e.g., less than 0.5 mm).

This is illustrated more clearly by reference to Graph 1, which is attached hereto as Exhibit 1. Graph 1 shows the relationship between X, the fracture rate of hollow material, and the dielectric constant of a molded product containing the hollow material. The value of X can be calculated using equation (a), set forth on page 14, line 3 of the Specification, for the examples and comparative examples described in the present application. Equation (a) reads as follows:

$$\rho = 100/[\alpha/\rho 1 + \beta/\rho 2 + \gamma(1 - X)/\rho 3 + \gamma X/\rho 4] \quad - \quad (a)$$

and can be solved for X to provide:

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$$X = [100/\rho - \alpha/\rho 1 - \beta/\rho 2 - \gamma/\rho 3]\rho 3\rho 4/[(\rho 3 - \rho 4)\gamma]$$

The values of fracture rate, X, and dielectric constants obtained from the data of examples 1 through 6 (E1-E6) and comparative examples 1, 3 and 4 (C1, C3 and C4), as described at pp. 16-21 of the present Specification, can be plotted to provide the attached Graph 1.

In Graph 1, it can be seen that there is a remarkable difference between the first area in which X is less than 0.1 and the second area in which X is greater than 0.1. In the first area, where X is less than 0.1, even slight variations in the fracture rate of hollow material (X) results in dramatic changes in the dielectric constant. By contrast, in the second area, where the fracture rate X is greater than 0.1, the dielectric constant changes very little with changes to the fracture rate, and the value of the dielectric constant is relatively high, i.e. greater than 3.0.

Turning to the cited Maeda reference, the fracture rate discussed in Maeda has the same meaning as used in the present invention, though in the present invention X is defined by a ratio, and in Maeda the fracture rate is defined by a percent. In Maeda, the range of fracture rate, X, is from 0.121 (12.1% in

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Example 3) to 0.326 (32.6% in Example 2). If one were to plot the fracture rate X of Maeda on Graph 1, all of the X values in Maeda are over 0.1, and therefore the estimated dielectric constants for all of Maeda's examples are over 3.

With respect to the relationship between specific gravity and the dielectric constant of a resin molded product, reference is made to Graph 2, which is attached hereto as Exhibit 2. According to the present invention, the dielectric constant of a molded product is improved by compounding a spherical hollow material containing air having a low dielectric constant with a wholly aromatic liquid crystal polyester. The specific gravity of the molded product is thus reduced by introducing an air phase into the composition. On the other hand, the specific gravity of the composition is increased (made worse), and the dielectric constant is increased (made worse), by compounding a filler other than a hollow air-containing material. Similarly, when the hollow material is destroyed during the production of the compound or the molding of the product, the specific gravity and the dielectric constant of the product are both increased (made worse). From these facts, it is inferred that there exist a certain relationship between the specific gravity and the dielectric constant of a molded product.

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The values of specific gravities and dielectric constants obtained from examples 1-6 (E1-E6) and comparative examples 1-6 (C1-C6) of the present specification are plotted in Graph 2. As can be seen from Graph 2, generally as the specific gravity becomes lower, the value of the dielectric constant is reduced (i.e., improves). However, regarding comparative example 1 (C1) and comparative example 3 (C3), while the specific gravity in these examples is low, the dielectric constant for these examples is high and in excess of 3.0. The fracture rates of inorganic spherical hollow material (X) for comparative examples 1 and 3 are 0.46 and 0.36, respectively. The improvement effect of the hollow spherical filler for dielectric constant of the composition strongly decreases with an increase in the fracture rate, X.

When the fracture rate of inorganic hollow spherical material is high, assuming that the increase of dielectric constant occurs only by decrease of an effective air phase and residue of fractured hollow material, the molded product having no hollow material or having low fracture rate would be expected to maintain the relationship between specific gravity and dielectric constant. However, contrary to this, the dielectric constant becomes worse. From this fact, it is presumed that a large fracture rate of

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hollow material would make other bad influence upon the dielectric constant.

In the examples of the present invention, example 3 (E3) shows the highest specific gravity of 1.20 and the value of the dielectric constant is 2.91, which is the highest value of the examples of the present invention. The specific gravities in the examples of Maeda range from 1.21 (Example 3) to 1.32 (Example 5). If one plots those values of the specific gravity of Maeda on Graph 2, all of the values exceed the highest value of the examples of the present invention. In fact, the estimated dielectric constants of the Maeda examples all exceed 3.0.

Therefore, according to the present invention, a molded product having a dielectric constant of 3.0 or less and a dielectric dissipation factor of 0.04 or less provides suitable dielectric properties for information transmission equipment and excellent heat resistance, as well as excellent flowability suitable for molding a product having a thin part with a thickness of 0.5 mm or less, for example.

These unexpected results are obtained by using a liquid crystal polyester having excellent flowability. The flowability feature minimizes the fracturing of hollow filler material during a molding process. This flowability feature is recited in the

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present claims as an apparent viscosity of 5,000 poise or less, as measured at a temperature of 20 deg. C above the melting point of the wholly aromatic liquid crystal polyester. Maeda does not teach or suggest this feature. Furthermore, since Maeda does not achieve the dielectric properties of the present invention, it is understood that Maeda does not have the flowability properties defined by the apparent viscosity as claimed by claim 1.

Therefore, Maeda does not teach any liquid crystal polyester compound having a dielectric constant of 3.0 or less, nor does Maeda disclose or suggest the flowability of a liquid polyester material for achieving such a low dielectric constant.

The secondary reference to Tanaka discusses a polyphenylene sulfide resin composition comprising 40-70 wt % of a polyphenylene sulfide resin composition, 18-30 wt % of a polytetrafluoroethylene powder having an average particle diameter of 1-5 micro meter, 2-7 wt % of a polyolefin resin, and 10-40 wt % of a fibrous reinforcing material. In Maeda, a liquid crystal polyester resin and a hollow sphere are essential components. However, the polymers described in Tanaka (polyphenylene sulfide, polytetrafluoroethylene and polyolefin) are clearly different from the liquid crystal polyester. Also, Tanaka does not teach or suggest a hollow spherical material. Therefore, since Maeda and

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Tanaka describe such different materials, there is no suggestion or motivation to combine these references. Furthermore, Tanaka does not teach the presently-recited dielectric constant and dielectric dissipation factor. These are claimed features of the present invention and are achieved by the composition comprising a wholly aromatic liquid crystal polyester having a melting point of 320 deg. C or more and an apparent viscosity at a temperature of 20 deg. C above the melting point of the polyester of 5,000 poise or less, and an inorganic spherical hollow material having an aspect ratio of 2 or less.

Accordingly, it is submitted that the invention as defined by the present claims is novel and not obvious in view of Maeda and Tanaka, and that claims 1, 2 and 4-9 should be allowed.

The provisional rejection of claims 1-9 for double patenting over the claims of co-pending application no. 11/578,980 is acknowledged. Applicants will address any outstanding double patenting issues once allowable claims are found in this application or in the 11/578,980 application.

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The Examiner is encouraged to telephone the undersigned attorney to discuss any matter that would expedite allowance of the present application.

Respectfully submitted,

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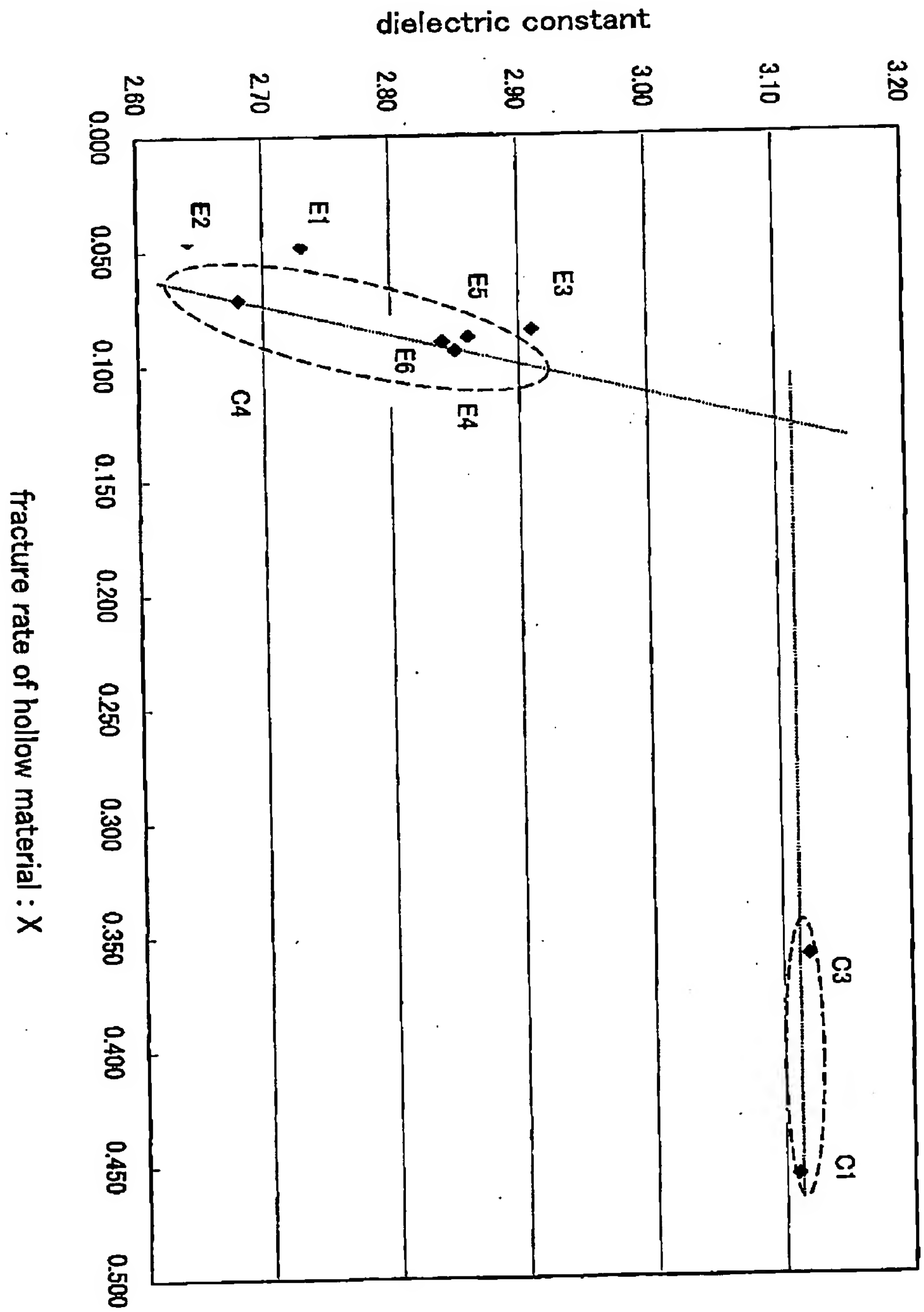
Title: Wholly Aromatic Liquid Crystal Polyester Resin ...
Inventor Name: Murouchi et al.
Appl. No. 10/519,046
Docket No.: AK-481XX

Exhibit 1



Graph 1

Title: Wholly Aromatic Liquid Crystal Polyester Resin ...
Inventor Name: Murouchi et al.
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Exhibit 2

Graph 2